SYSTEMS ENGINEERING FUNCTIONAL REQUIREMENTS

for:

STANDARD TRAFFIC SIGNAL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Contract Number:

Approval Date:

Prepared by:

Document Control Number:

Revision Version & Date:

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1.0 SCOPE OF APPLICATION PACKAGE

This report provides ***Functional Requirements*** (*FRs*) for a standard traffic signal and for optional features that may or may not apply to this particular project. Please see the corresponding *Minnesota Statewide Regional ITS Architecture and Systems Engineering Checklist* (*Checklist)* for the project to identify which specific features apply and other pertinent site details. Regardless of the selected options, all traffic signals include the *FR* for the .1 Basic Traffic Signal. Following are the name and numbering identifier for the various features that may apply:

.1 – Basic Traffic Signal (common to all)
.2 – Flashing Yellow Arrow (FYA)
.3 – Advance Warning Flasher (AWF)
.4 – Railroad Preemption (RRP)
.5 – Emergency Vehicle Preemption (EVP)
.6 – Transit Signal Priority (TSP)
.7 – Enforcement Lights
.8 – Traffic Signal Interconnect.
.9 - Other

The *FRs* are categorized by the above Traffic Signal features.

1.1 Basic Traffic Signal (BTS)

A traffic signal provides standard red-yellow-green operation and will have actuated or fixed time operation plus the following:

- Emergency Vehicle Preemption (EVP) wiring
- Design that follows the latest version of *Americans with Disability Act Accessibility Guidelines for Buildings and Facilities (ADAAG),* as cited in the *2005 MN MUTCD* and the *Public Rights of Way Accessibility Guidelines (PROWAG)* as adopted by Mn/DOT.

EVP wiring is included to allow for easy future addition of hardware and control software to expedite emergency vehicle movement on one or more approaches of the intersection (police, fire, ambulance).

The traffic signal may include detection and, and may be either isolated or part of a closed loop, interconnected system, as shown on project plans.

1.2 Flashing Yellow Arrow (FYA)

The FYA is a new optional feature in the 2009 national *MUTCD* (primarily Sections 4D.17-.30) that is expected to be adopted in Minnesota. It is used to delineate permissive left or right turn movement, as opposed to protected left or right turn movement.

1.3 Advanced Warning Flasher (AWF)

An AWF installation is the addition of a sign with flashing yellow sections to alert drivers approaching a high speed signalized intersection that the light is about to turn from the green phase to red phase (see *ConOps* Section 1.2). The yellow flashers are activated any time an approaching vehicle is likely to arrive at the signal during a red signal phase. The main goal is to remove indecision in the dilemma zone when the signal changes from yellow to red.

1.4 Railroad Preemption (RRP) of Traffic Signal at Highway-Rail Grade Crossing

RRP of traffic signals is used to clear highway-rail grade crossings and maintain the clearance while the train passes to avoid a collision between trains and vehicles or people. The application context is heavy rail in which trains cannot stop over short distances and for which RRP is required.

Regardless of the operational mode, the pre-emption response of the traffic signal controller is site specific, depending on the physical configuration of the highway-rail grade crossing and the location of adjacent traffic signals. In all cases, the control logic must clear vehicles off the railroad tracks by special pre-emption phasing and timing.

1.5 Emergency Vehicle Preemption (EVP)

EVP is used to support safe and expeditious movement of police, fire, ambulance, or other critical emergency service vehicles through a signalized intersection. The basic concept is that an emergency vehicle that needs to travel as quickly as possible to or from an incident scene requests high priority movement through all or many of the signals on its travel route by either a call to a central control system, or by emitting an advance request for preemption service to each properly instrumented signal on its route. The signal or signals then grant right of way to the emergency vehicle, minimizing the chances of vehicles on conflicting approaches entering the emergency vehicle's path. Unlike RRP, EVP is not absolute in the sense that preemption is not necessarily granted in all cases, for example, when EVP has already been granted for an emergency vehicle on a conflicting approach.

1.6 Transit Signal Priority (TSP)

TSP is similar to EVP but with a lower priority to force a green extension or early truncation of red. Typical implementations are based of active tracking of bus passage times relative to scheduled passage times at route checkpoints. If a bus is running ahead of schedule, TSP activation is inappropriate because it may then put the bus further ahead of schedule. The level of priority to grant must be determined on an individual route or site basis. The location of bus stop affects the determination of this, with near side stops having the additional complication that bus dwell time for boarding and alighting passengers is variable such that the true desired "green" time for the bus is not known much in advance. The scope of TSP here is implementation on a localized basis only (individual buses and traffic signals), i.e., without control center oversight.

1.7 Accessible Pedestrian Signal (APS)

APSs provide information in non-visual format by both audible messages and vibrating surfaces. Pedestrian signal timing must be used as well, and APS detection may also be needed. Placement of devices is particularly important so that persons making use of them can readily recognize where they are, to what crossing they apply, and can easily activate associated detection when part of the design.

1.8 Countdown Pedestrian Signals (CPS)

A CPS provides second-by-second visual display of the number of seconds remaining in the pedestrian change interval, located adjacent to the associated upraised hand ("Don't Walk"). The display counts down only during display of the adjacent flashing upraised hand, displays zero when the upraised hand changes to steady display, then blanks out. Section 4E.7 of the *2005 MN MUTCD* spells out further details.

1.9 Enforcement Lights (EnL)

EnL are special displays placed on the back or the side of signal for the benefit of an enforcement officer to see when the red indication is displayed. This allows the enforcement officer to see whether or not a driver has illegally entered the intersection approach on red and should have a violation cited.

1.10 Traffic Signal Coordination (TSC)

TSC is the establishment of timed traffic flow between traffic signals to minimize delays and stops on a progressively timed arterial or in a grid. The signals may be interconnected via wireline or wireless communications, or progressive timing may be established using time-based coordination. System supervision and oversight may be by standard closed loop signal packages from established suppliers or may use custom software. The scope here is standard coordinated signal systems and not "smart" or "enhanced" corridors that have additional features.

1.11 Other

[Reserved for new features and their characteristics. Please consult with appropriate Mn/DOT, FHWA, or local staff to develop needed scope description.]

2.0 REFERENCE DOCUMENTS

See *ConOps* Section 2. To that list add:
National ITS Architecture, V 6.1, http://www.iteris.com/itsarch/index.htm

3.0 FUNCTIONAL REQUIREMENTS AND VERIFICATION METHOD

Table 1 lists the pertinent Functional Requirements including Verification Method. Table 2 maps the ITS Needs and Services that were identified in the companion *ConOps* document for each feature (Table 2 of that document) to the *FRs* identified here, for traceability from the *ConOps* to the *FRs*.

4.0 SUPPORTING DOCUMENTATION

See associated *Checklist* for additional support documents.

Table 1 Functional Requirements for Standard Traffic Signal

ID	Functional Requirement	Verification Method*	Comments
TS-BTS	*Basic Traffic Signal Requirements*		
TS-BTS-1	The field element shall control traffic using fixed time or actuated timing as specified in the plans, and under central control where specified. The signal shall use standard red-yellow-green indications with design and operation in conformance with the *2005 MN MUTCD* to optimize efficiency and safety.	I, D	
TS-BTS-2	The field element shall include wiring for emergency vehicle preemption (EVP).	I, D	
TS-BTS-3	The field element shall include a local interface that provides operational status and fault data for connected field equipment to field personnel.	I, D	
TS-BTS-4	The field element shall include a local interface that allows field personnel to conduct diagnostic tests on connected field equipment.	I, D	
TS-BTS-5	The field element design shall address *Americans with Disability Act Accessibility Guidelines (ADAAG)* as required in Sec 4D.19 of the *2005 MN MUTCD* and *Public Rights-of-Way Accessibility Guidelines (PROWAG)* as adopted by Mn/DOT.	I, D	
	Pedestrian Aspects		
TS-BTS: PED-1	When specified in the plans, the field element shall include pedestrian signal faces, push buttons, and timing.	I, D	
TS-BTS: PED-2	Except when other requirements supercede it, the field element shall include Accessible Pedestrian Signals (APSs) that provide both audio and vibrotactile indication of "WALK/DON'T WALK" intervals wherever pedestrian signal faces are provided.	I, D	
TS-BTS: PED-3	When specified in the plans, the field element shall include APS pushbutton detectors that are active or passive. Active detectors shall include a pushbutton locator tone.	I, D	

* D - Demonstration
T - Test
A - Analysis
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Table 1 Functional Requirements for Standard Traffic Signal (continued)

ID	Functional Requirement	Verification Method*	Comments
Pedestrian Aspects (continued)			
TS-BTS: PED-4	The field element shall include Countdown Pedestrian Signal (CPS) faces that provide display of seconds remaining in the pedestrian change ("Flashing DON'T WALK") interval.	I, D	
TS-BTS: PED-5	CPS faces shall be blank except when counting down in integer numbers to and through "0" during the pedestrian clearance interval.	I, D	
TS-BTS: PED-6	When specified in the plans, the field element shall collect pedestrian images and pedestrian sensor data, and respond to pedestrian crossing requests via display, audio signal, or other manner.	I, D	
Detection Aspects			
TS-BTS: DET-1	When specified in the plans, the field element shall include loop or other detection on identified approaches.	I, D	
TS-BTS: DET-2	When specified in the plans, collected field data from the site shall be archived at a central location for use in traffic analysis, planning, studies, and performance measurement. Archived data at a minimum shall consist of volume, occupancy, and speed.	I, D	
Monitoring Aspects			
TS-BTS: MON-1	When specified in the plans, the field element shall monitor operation of the traffic signal controller(s) and report to the center any instances in which the indicator response does not match that expected from the indicator control information.	I, D	
TS-BTS: MON-2	When specified in the plans, the field element shall monitor operation of traffic signal controllers and report to the center any instances in which the indicator response does not match that expected from known indicator preemptions.	I, D	

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Table 1 Functional Requirements for Standard Traffic Signal (continued)

ID	Functional Requirement	Verification Method*	Comments
	Monitoring Aspects (continued)		
TS-BTS: MON-3	When specified in the plans, the field element shall return traffic signal controller operational status to the control center.	I, D	
TS-BTS: MON-4	When specified in the plans, the field element shall return traffic signal controller fault data to the maintenance center for repair.	I, D	
	Interface Aspects		
TS-BTS: IFC-1	When specified in the plans, the field element shall include traffic sensors that provide data and status information to other field element devices (such as other traffic signals, dynamic message signs, ramp meters, work zone intrusion alert systems), without center control.	I, D	
TS-BTS: IFC-2	When specified in the plans, the field element shall include traffic sensors that receive control information from other field element devices, without center control.	I, D	
TS-BTS: IFC-3	When specified in the plans, the field element shall include arterial signal controllers that provide data and status information to other field element devices (such as traffic controllers at adjacent intersections and dynamic message signs), without center control.	I, D	
TS-BTS: IFC-4	When specified in the plans, the field element shall include arterial signal controllers that receive control information from other field element devices, without center control.	I, D	
TS-FYA	*Flashing Yellow Arrow Requirements*		
TS-FYA-1	When specified in the plans, the field element shall include Flashing Yellow Arrows (FYA) on the identified approaches that indicate permissive vehicle movement when activated.	I, D	

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Table 1 Functional Requirements for Standard Traffic Signal (continued)

ID	Functional Requirement	Verification Method*	Comments
TS-AWF	*Advanced Warning Flasher Requirements*		
TS-AWF-1	When specified in the plans, the field element shall include Advanced Warning Flashers (AWF) on the identified approaches tied to signal phasing and timing for activation.	I, D	
TS-AWF-2	AWF shall be set up and timed to flash a warning to approaching drivers that the signal has turned or is about to turn to red.		
TS-RRP	*Railroad Preemption*		
TS-RRP-1	When specified in the plans, the field element shall include Railroad Preemption (RRP) in which the adjacent railroad track circuit is interfaced with the traffic signal to provide grade crossing clearance and protection.	I, D	
TS-RRP-2	RRP shall provide fail-safe operation in coordination with other protection devices, such as flashers and gates, to clear the tracks of conflicting objects and persons and hold the protection throughout the train crossing time.	I, D	
TS-RRP-3	RRP shall revert to normal traffic signal operation through pre-determined signal phase sequencing and timing.	I, D	
TS-EVP	*Emergency Vehicle Preemption*		
TS-EVP-1	When specified in the plans, the field element shall include Emergency Vehicle Preemption (EVP) in which green time is extended or red time is truncated to improve safety and expedite the movement of authorized emergency vehicles on the identified approach(es).	I, D	
TS-EVP-2	EVP shall include confirmatory lights that indicate to emergency vehicle drivers whether or not preemption has been granted.	I, D	
TS-EVP-3	EVP shall revert to normal traffic signal operation through pre-determined signal phase sequencing and timing.	I, D	

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Table 1 Functional Requirements for Standard Traffic Signal (continued)

ID	Functional Requirement	Verification Method*	Comments
TS-TSP	*Transit Signal Priority*		
TS-TSP-1	When specified in the plans, the field element shall include Transit Signal Priority (TSP) in which green time is extended or red time is truncated to expedite the movement of transit vehicles on the identified approach(es). Preemption control for RRP or EVP shall take precedence over TSP.	I, D	
TS-TSP-2	TSP shall include rules to negotiate competing calls for priority and allowed frequency of TSP operation.	I, D	
TS-TSP-3	TSP shall revert to normal traffic signal operation through pre-determined signal phase sequencing and timing.	I, D	
TS-EnL	*Enforcement Lights*		
TS-EnL-1	When specified in the plans, the field element shall include Enforcement Lights (EnL) that provide confirming display of red signal indications to support red light running enforcement.	I, D	
TS-EnL-2	EnL shall be placed in a location so that enforcement personnel can observe the EnL and the associated approach to allow the personnel to pull out and pursue a red light running driver from a safe location.	I, D	
TS-TSC	*Traffic Signal Coordination*		
TS-TSC-1	When specified in the plans, the field element shall include Traffic Signal Coordination (TSC) that allows the signal to be sequenced and timed with adjacent signals to provide progressive traffic movement.	I, D	
TS-Oth	*Other*		
TS-Oth-1	*[Develop as appropriate]*		

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Table 2 Mapping of Standard Traffic Signal Needs/Services to Functional Requirements

Feature	Needs/Services		ITS Functional Requirements
Basic Traffic Signal	TM01	Provide efficient signal timing	TS-BTS-1, -5
	TM03	Use archived data for traffic management strategy development and long range planning.	TS-BTS-DET-2
	TM14	Monitor operation and performance of traffic signals	TS-BTS-3, -4; TS-BTS: MON-1 thru -4
	TM37	Provide safe signal phase transition	TS-BTS-1
Pedestrian Aspects	--		TS-BTS: PED-1, -2
Detection Aspects	TM01	Provide efficient signal timing	TS-BTS-1; TS-BTS: DET-1
	TM33	Provide intersection collision avoidance systems	TS-BTS-1
	TM37	Provide safe signal phase transition	TS-BTS-1
Monitoring Aspects	TM14	Monitor operation and performance of traffic signals	TS-BTS-3, -4; TS-BTS: MON-1 thru -4
Interface Aspects	TM01	Provide efficient signal timing	TS-BTS: IFC-1 thru -4
Flashing Yellow Arrow	TM01	Provide efficient signal timing	TS-BTS-1; TS-FYA-1
	TM37	Provide safe signal phase transition	TS-FYA-1
Advanced Warning Flasher	TM33	Provide intersection collision avoidance systems	TS-AWF-1, -2
	TM37	Provide safe signal phase transition	TS-AWF-1, -2
Railroad Preemption	TM28	Provide railroad flashing light signals and gates	TS-RRP-1 thru -3
	TM38	Provide health monitoring of rail crossings	TS-BTS: MON-2, -4
Emergency Vehicle Preemption	--		TS-BTS-2; TS-EVP-1 thru -3
Transit Signal Priority	TR15	Optimize schedule efficiency	TS-TSP-1 thru -3
	TR17	Coordinate transit vehicle movements with traffic control devices	TS-TSP-1 thru -3
Enforcement Lights	TM02	Implement red-light running technology	TS-EnL-1, -2
Traffic Signal Coordination	TM01	Provide efficient signal timing	TS-TSC-1
Other		*[Develop as needed]*	

Needs/Services per *Minnesota Statewide Regional ITS Architecture* (March 2009)

Needs/Services Key:
TM - Traffic Management
TR - Transit

See Table 1 for Functional Requirements content.